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MULTIPLE RESOURCE EVALUATION OF REGION 2 U.S. FOREST SERVICE LANDS UTILIZING LANDSAT MSS DATA

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September 1975, QUARTERLY PROGRESS REPORT
For Period June 1 - August 31, 1975

NASA CONTRACT NAS 5-20948

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16. Abstract Extensive field studies have been conducted in the Southern San Juan Mountains Planning Unit in support of LANDSAT data analysis. Using data tapes from LANDSAT-1 frame no. 1424-17132, LARS generated grey scales in 4 bands, selected a grid of test fields, and began work with the cluster maps for training the computer to recognize spectral classes related to vegetation. Ground truth information for the test field grid was gathered. Landtype association level can be accurately mapped from either the stereo portion of LANDSAT images or the computer enhanced products from LANDSAT MSS computer compatible tapes. Landtype level, the next heiracheal subdivision, can be partially mapped from color infrared stereo pairs of derived computer enhanced products from LANDSAT data. The Forest Service planning team has interacted with all phases of this research effort.					
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TYPE II THREE MONTH PROGRESS REPORT

For the period beginning June 1, 1975 and ending August 31, 1975

A. Title: Multiple Resource Evaluation of Region 2, United States
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B. Principal Investigator: Dr. Paula V. Krebs
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C. Problems Encountered.

There were several minor problems encountered during the field season. The lack of adequate aircraft coverage as explained in the June 1, 1975 quarterly report hampered the final selection of sites for intensive field work. Ground reconnaissance for location of areas of particular cover types took longer than preliminary location on aerial photographs would have. Forest Service personnel have been very helpful with the location of some sites based on their extensive field experience in the area. However, at the end of the field season, there is adequate data for analysis and evaluation of all important cover types found in the study area.

Another problem was the heavy snowfall and late spring this year in the San Juan Mountains. Road travel was often limited by mud or snow drifts, hiking was restricted by deep, rotten snow at higher altitudes, and by swollen creeks and rivers. Vegetation mapping of alpine areas and avalanche tracks was hampered by many late lying snowbanks, some lasting the entire season. Previous ecological knowledge of alpine ecosystems was necessary to map bare rocks and soil, tundra, alpine willow, and krummholz areas.

The third item which may become a problem is obtaining another acceptable LANDSAT frame for comparative purposes with the September 20, 1973 frame (frame no. 1424-17132) currently being used for the vegetative classification. A clean LANDSAT-2 frame taken June 4, 1975 (frame no. 2133-17085) is excellent for the study area, however, much of the area above 11,000 ft. (3355 m) is covered with snow. Another LANDSAT-2 frame on July 9, 1975 (frame no. 2168-17031) has minimal cloud cover, but the clouds present are directly over the study area. The latter half of July and most of August have followed the usual weather pattern for the area and have been exceptionally cloudy. However, we anticipate getting a good frame on one of the passes in late August or during September before the fall storms again cover the high elevations with snow.

D. Accomplishments.

During the past quarter the LANDSAT consortium has been occupied with extensive field studies, preliminary work on a stereo model for landform mapping, and preparation of the LANDSAT data tapes for a vegetation classification. The U. S. Forest Service personnel from the three National Forests participating in the Southern San Juan Mountains Planning Unit have continued development of their management plan for the study area. One of the major thrusts of this planning effort is the development of the planning process. If a successful planning process results from the Southern San Juan Mountains Planning Unit, portions of the process will be incorporated throughout the National Forest system. During the field season Forest Service planning team members directly interacted with the INSTAAR research team. On several occasions the Forest Service and INSTAAR personnel worked together in the field situation.

D. 1. Laboratory for Applications of Remote Sensing Activities.

During this reporting period LARS began work on a preliminary classification of the vegetation for the Southern San Juan Mountains Planning Unit using data from LANDSAT-1 frame no. 1424-17132. Gray scales of the whole planning unit were generated for each of the four bands at a scale of 1:48,000. Selected portions of the gray scale printout at 1:24,000 were produced for the more detailed analysis and preliminary work on a stereo model by INSTAAR.

A grid of test fields was delineated on the gray scale for the intensive study areas of the planning unit. Each test field is 4 x 4 pixels in area (approximately 7.4 hectares) and is separated by four pixels from the next test field. The areas finally selected for intensive field work are as follows (Fig. 1):

- Platoro, entire quadrangle
- Summitville, south $\frac{1}{2}$
- Spectacle Lake, entire quadrangle
- Chromo NE, entire quadrangle
- Wolf Creek Pass NE, entire quadrangle

Some test fields were also selected from Osier, Big Horn, and Brazos NE quadrangles.

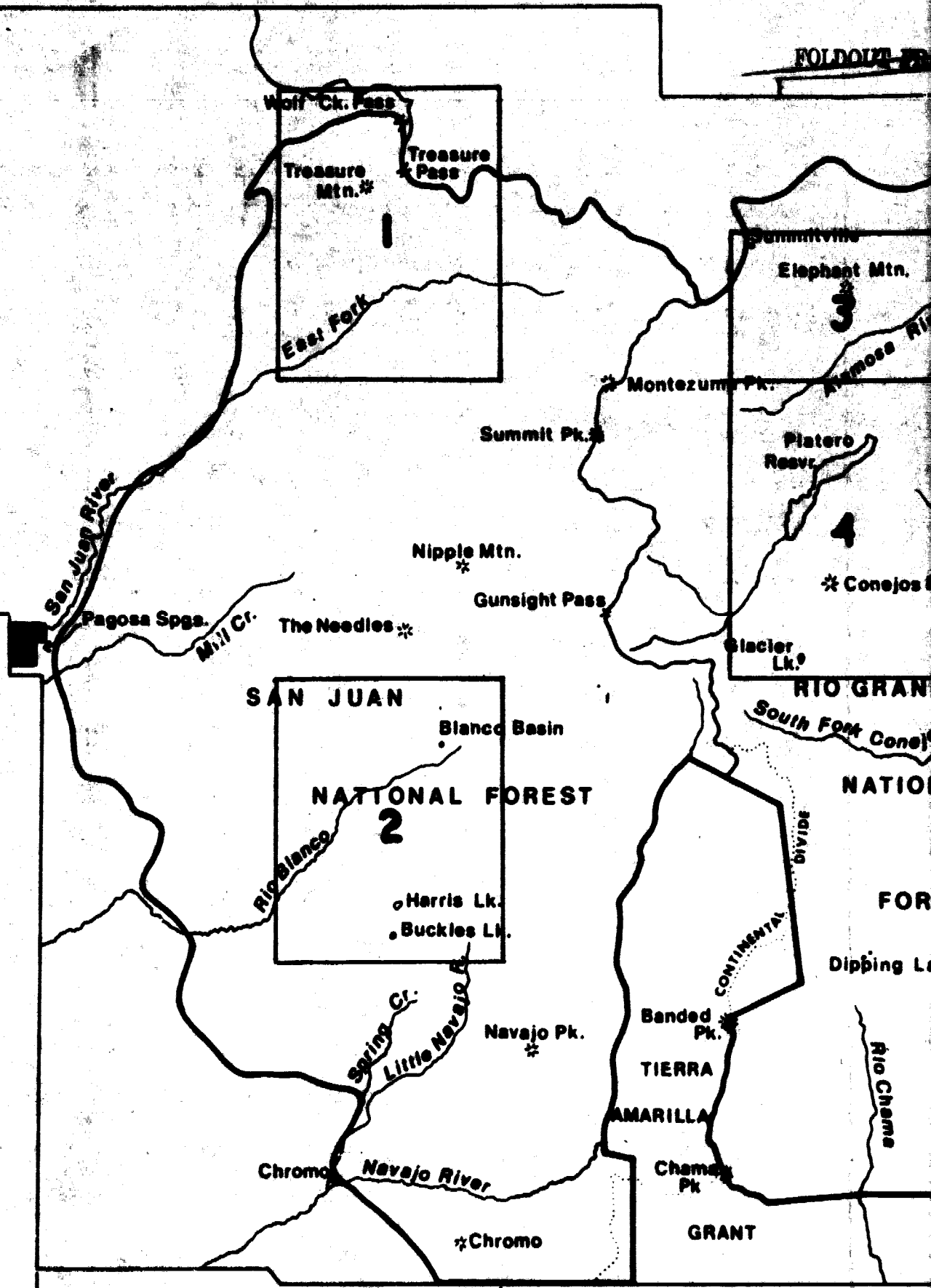
Five training areas were selected near Platoro Reservoir and the upper Conjos River in the Rio Grande National Forest. One includes the tundra areas around Conjos Peak, another the spruce/fir meadow, and aspen complex at the west end of Platoro Reservoir, a third the mosaic of disturbance around Platoro dam and the old mining community of Platoro, the spruce/subalpine fir, aspen, douglas fir, meadow, and riparian communities. Each training area was clustered independently into 12 to 16 cluster classes. The optimum number of cluster classes used for each training area was selected by minimizing the transformed scatter ratio. Preliminary identifications of the clusters were made using Forest Service 1:15,840

Figure 1. Locations of J.S.G.S. $7\frac{1}{2}'$ quadrangles for intensive field work in the Southern San Juan Mountains Planning Unit.

1. Wolf Creek Pass NE
2. Chromo NE
3. Summitville, south $\frac{1}{2}$
4. Platoro
5. Spectacle Lake
6. Osier
7. Brazos Peak NE
8. Bighorn Peak

FOLDOUT FRAME 1

FOLDOUT FRAME 2



107°00'

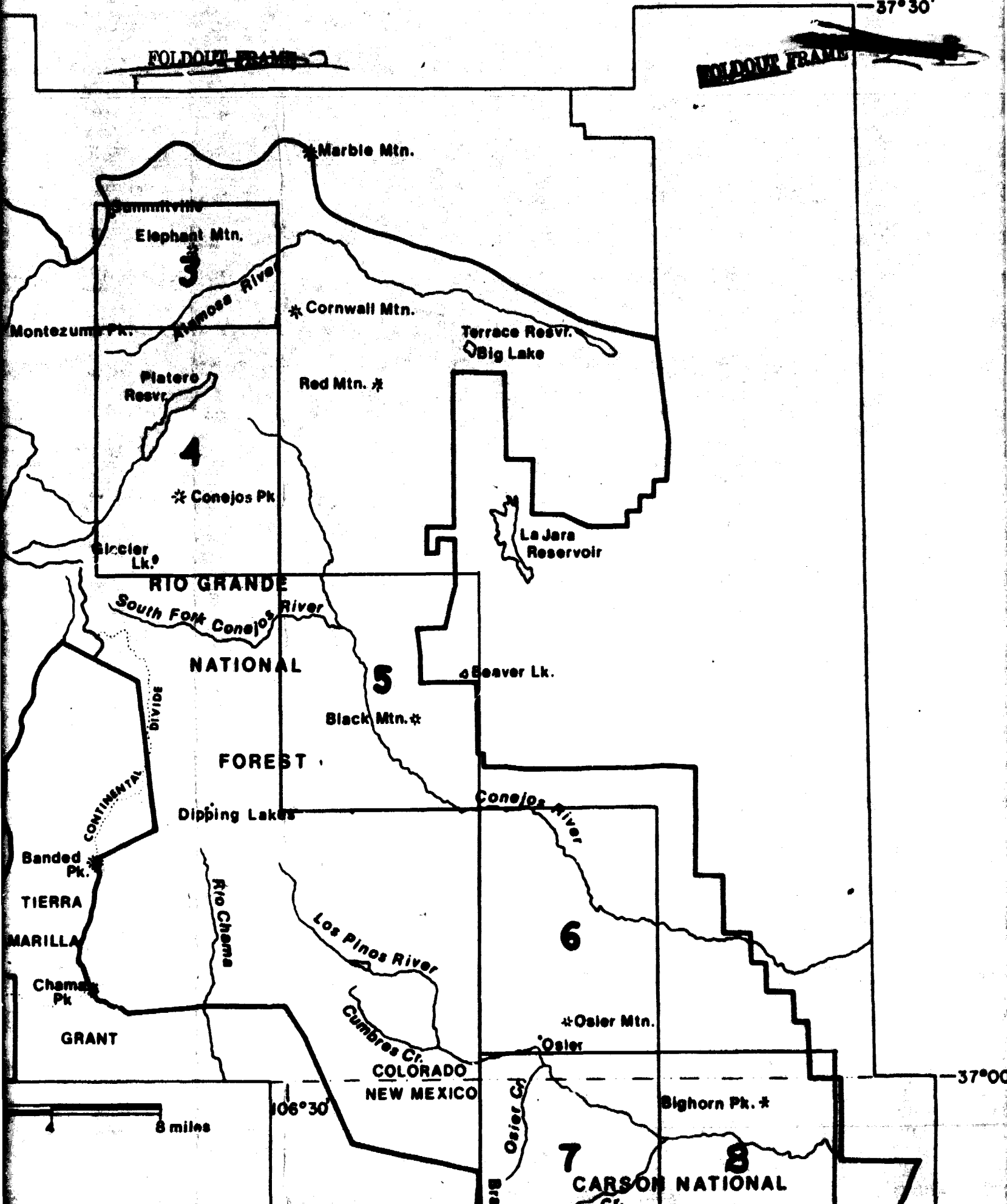
106°45'

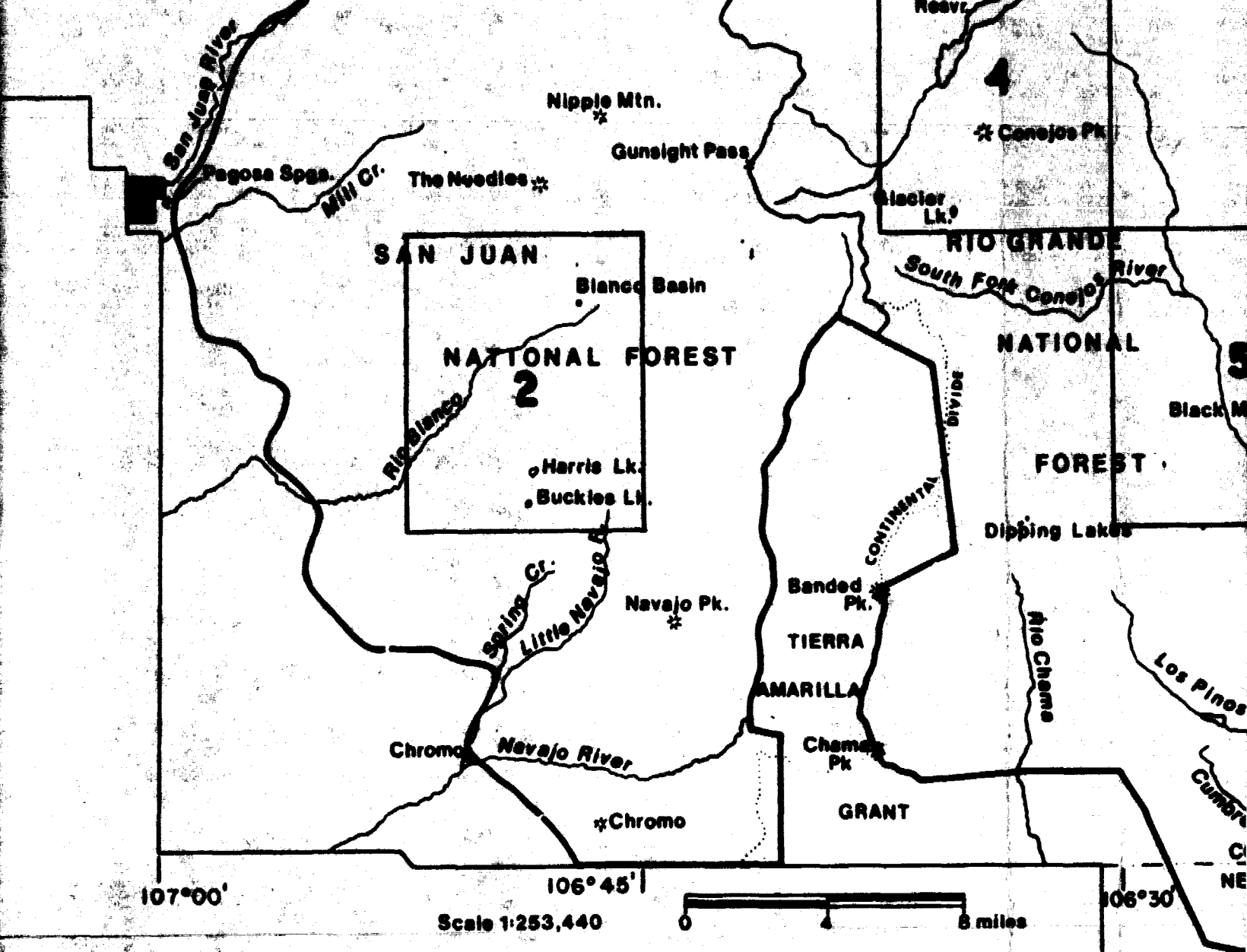
Scale 1:253,440

0 4 8 miles

FOLDOUT FRAME

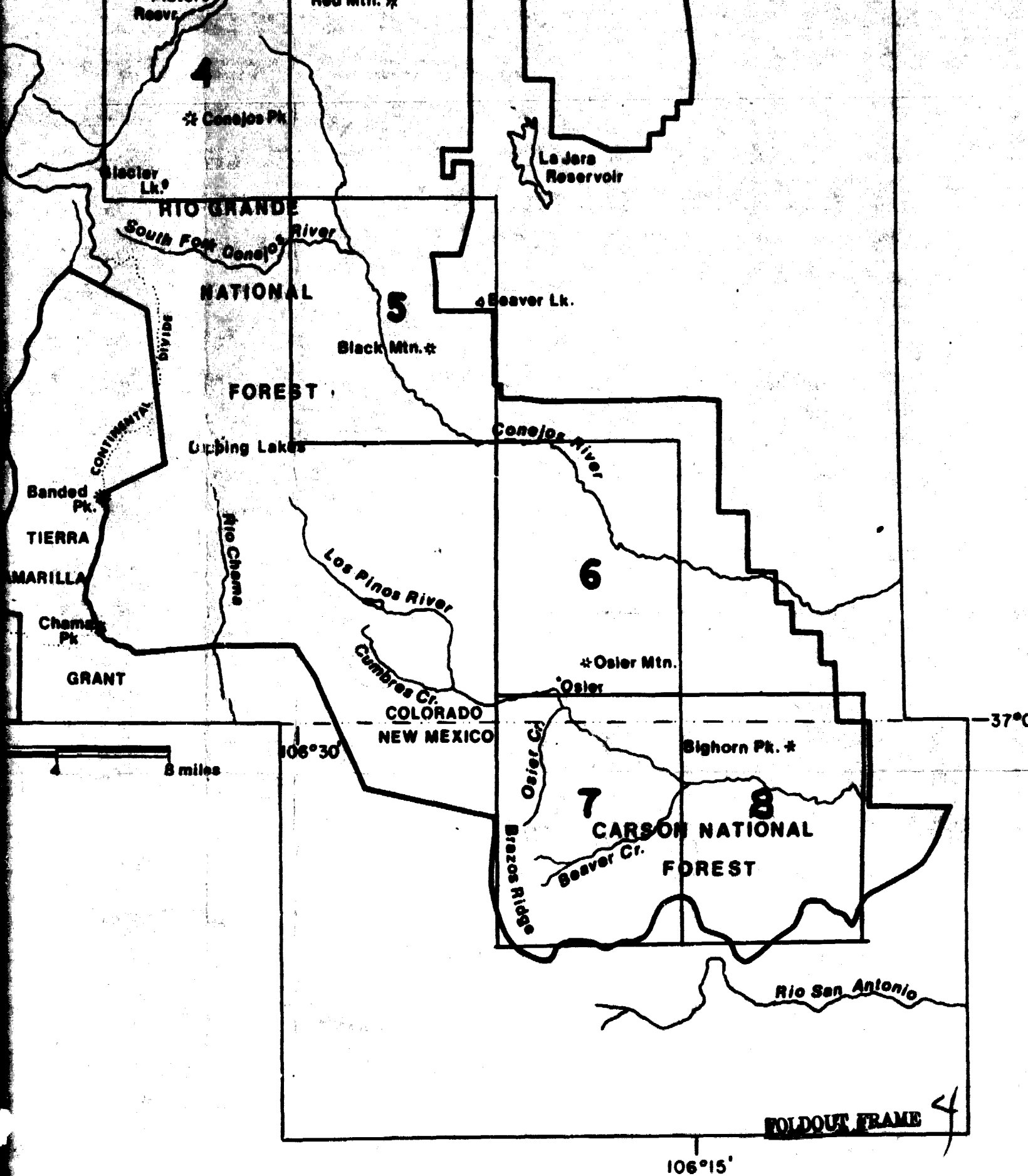
FOLDOUT FRAME





FOLDOUT FRAME 3

4a



color aerial photography. Lack of aerial photography has hampered the selection of additional training fields, especially in the areas of pinon/juniper, oak, ponderosa/oak, and shrubs important in the Carson and San Juan National Forests. When final processing is completed of the aircraft coverage flown by NASA of the planning unit in late June, 1975, some of this problem should be alleviated.

LARS has produced several digital display products to be used by INSTAAR for preliminary work on the stereo model for land form mapping, and for Forest Service orientation. Computer-enhanced products simulating false color infrared from the LARS digital display can provide the Forest Service with a more detailed look at their area of concern than is possible with the images from EROS Data Center. Digital display products for the stereo model were taken from LANDSAT-1 frames no. 1424-17132 and 1425-17190 which provide stereo overlap for 60% of the planning unit. For an initial evaluation of the stereo model an area at the head waters of the Conchos and Alamosa rivers was selected and gray scales of each band were generated at different scales. False color infrared products combining three bands were also made for the initial evaluation by INSTAAR.

In late July, Mike Fleming from LARS, made a site visit to the INSTAAR field camp in the planning unit. The trip provided an opportunity for a brief tour of the planning unit, to talk with Forest Service personnel, and for many valuable discussions with the INSTAAR team.

D. 2 Vegetation Mapping

Further discussions with Dr. Roger Hoffer, LARS, have led to a modification of the test field grid system used to evaluate the LARSYS classification. The test field grid system consists of automatically selected test fields, each 4 x 4 pixels in size and separated from the next test field by a 4 pixel border. A test field must have a homogenous cover type throughout the 16 pixels of the field, or it is discarded. The difficulty with this system however, is that some cover types such as rock outcrops, gravel bars, rivers, riparian and krummholz communities are seldom 4 pixels wide. The modified test field grid system selects one pixel from each test field as a test data point. The boundary of the cover type represented by the data point is then drawn in. Irregular boundary test fields can incorporate small areas of particular cover types. If necessary, the test field grid system can be overlayed on the irregular boundary test fields and the 4 x 4 pixel test fields falling within the irregular boundaries can be used to evaluate the LARSYS classification.

The field work in the Southern San Juan Mountains Planning Unit was conducted using the irregular boundary test field system. The pixel in the SW corner of each 4 x 4 pixel test field was used for the data point grid. This grid was transferred from the LANDSAT gray scales generated by LARS to U.S.G.S. 7½' topographic maps for field use. In the areas of the San Juan National Forest where only 15' maps were available, the Forest Service had enlarged the maps to 7½' equivalent, scale 1:24,000, and these were used for the field work. Each test data point was assigned a unique number within the planning unit.

The most accurate and efficient data collection in the field was usually obtained from a vantage point. Each data point in the field of view was located by corresponding topographic features of the landscape with the U.S.G.S. base maps. With careful observation most of the data points could be accurately located in the field. Sometimes difficulty was encountered due to changes in river beds, fire regeneration, new logging, or varying photointerpretation definitions by U.S.G.S., but these problems could be resolved with a little extra effort. Binoculars were invaluable for the field work, both in locating data points and for identifying the vegetative cover. Work was not conducted in the early morning, late evening or on stormy days when topographic shadow and haze made identification of tree species difficult.

When a data point had been located, the boundary is drawn on the map indicating the extent of the cover type represented at that point. The area within this boundary must be homogenous with respect to species composition, total crown closure, and crown closure by the species present. The cover type may extend beyond the boundaries drawn, but the area enclosed indicates what the observer was sure about. No effort was made to extend the boundaries beyond the field of view unless the observer had previously seen the additional area. This provides maximum accuracy of field work without errors resulting from inferences. The cover type is given an alpha-numeric designation according to the vegetation code developed (Table 1) and recorded on the maps and in field data books. This code has been revised slightly due to field experience to better fit the vegetation of the study area. For each data point the cover type, total crown closure, crown closure by species breakdown, understory if the overstory was less than 100%, and miscellaneous notes are recorded. As much information as was practical was gathered in the field. During further laboratory analysis data can be lumped or disregarded, which is easier than obtaining needed detail after the completion of the field season.

Many cover types result from certain ecological parameters such as snow accumulation, depth of soil, moisture regime, and past history of disturbance and stability. From the cover types and their inferred ecological significances, the Forest Service derives management decisions.

The three months of field work play a critical role in the success of this LANDSAT project. The test data points will be used as ground truth for evaluating the LARSYS classification. In the event that NASA had been unable to obtain satisfactory aircraft coverage for the planning unit due to bad weather conditions, the field data would have been the only reliable source of ground truth for most of the planning unit. Field experience aids the researcher in selecting areas for cluster maps used to train the computer in differentiating spectral patterns. Perhaps most important of all, field work gives the researcher an ecological familiarity with the study area. The researcher acquires a "gut level" feeling for the responses of the land and vegetation to topography and disturbances, as well as a better understanding of Forest Service management practices and problems.

Table 1. Alpha-numeric vegetation code.

<u>Biome Class</u>	<u>Symbol</u>	<u>Species</u>
Non-vegetated	00 01	bare rock/bare soil water
Vegetated		
graminoid	1	11 grassland (dry meadow) 12 meadow (moist meadow) 13 tundra
shrub	2	21 mountain mahogany 22 sage 23 shrubby cinquefoil 24 elderberry, raspberry, snowberry 25 alpine willow 26 rabbit brush 27 other shrubs
forested	3 Coniferous	1 juniper 2 pinyon pine 3 ponderosa pine 4 Douglas fir 5 white fir 6 blue spruce 7a bristlecone pine 7b limber pine 7c Mexican white pine 8 subalpine fir 9 engelmann spruce
	Deciduous	A aspen O oak
riparian	R	1 narrow-leaf cottonwood 2 birch/alder 3 willow

D. 3. Landform Mapping.

The U. S. Forest Service employs the Land Systems Inventory (Wertz and Arnold, 1972) for all levels of land use planning. The Land Systems Inventory is a hierarchical scheme of categorical levels of land base units. Each level within the system corresponds to specific planning needs. The broader class units are systematically subdivided into smaller, more homogenous and discrete units.

The U. S. Forest Service has selected the Southern San Juan Mountains Planning Unit as a type area for the development of landtype association level and landtype level (the next lower hierarchical level) analysis schemes. The landtype association level within the Land Systems Inventory recently has been documented for the planning unit (Brock, 1974). The landtype association level is utilized for broad resource planning for which the base is landform analysis. Landtype association level analysis has been completed using LANDSAT data. The landtype level units were not characterized and defined for the planning unit by the Forest Service. To attempt analysis of LANDSAT data at the landtype level the characterization and definitions of included units had to be developed.

D. 3. 1. Landtype Association Level.

LANDSAT imagery is a good tool for landtype association (Table 2) mapping. The landtype association categories selected for analysis have been derived by Forest Service personnel to meet regional planning needs, and in combination with forest complexes create ecological land units. The definitions for landtype associations are based on general slope percent ranges and land relief. LANDSAT imagery, when viewed in stereo, provides an adequate model to determine slope and local relief differences of small areas with sufficient detail to produce a good landtype association map.

Four LANDSAT frames were analyzed, two of which were taken on September 20 and 21, 1973 (LANDSAT frames 1424-17132 and 1425-17190) and two of which were January 29 and 30, 1973 (LANDSAT frames 1190-17145 and 1191-17204). Each set provided a stereo model, covering approximately 60% of the planning unit. The winter frames provided the clearest and sharpest model of the planning unit because of the snow enhancement of topographic features. The snow cover was light, incomplete, heavier in the higher elevations, and almost absent on the south facing slopes. For these reasons, the winter frames were chosen for analysis. Band 5, of the LANDSAT frames was chosen because of the greater tonal contrast. The stereo images were viewed over a light table with a Zeiss 8x mirror stereoscope. This was good for detail, but often a 3x power would have been better for a synoptic view. The stereo model provides analysis of only topographical geomorphic features. Surficial geologic and cultural features are difficult to distinguish.

Macro-dissection, which is a function of land slope regimes and elevation ranges, was the basis for delineation of landtype associations. Consistency in image interpretation is no problem in dissection and relief mapping.

Table 2. Landtype Association.

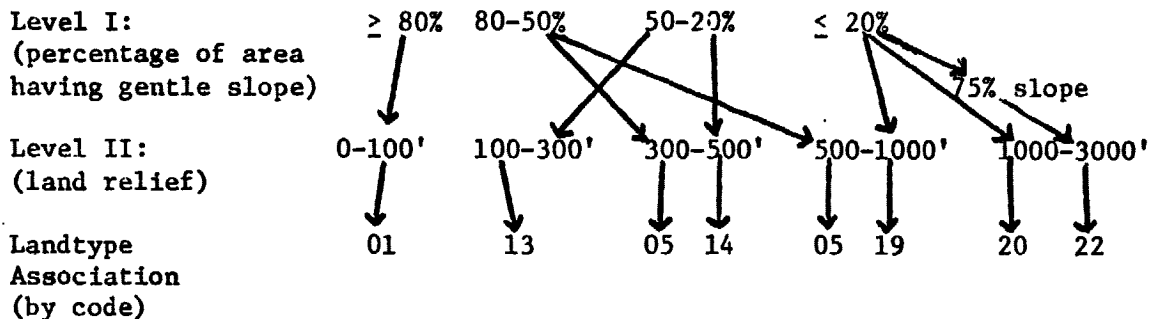
<u>Code</u>	<u>Name</u>	<u>Definition</u>
01	Bottom Lands	More than 80% of an area gently sloping and local relief variation ranges from 0-100 feet. Characterized by alluvial deposits. Slope rarely exceed 15%.
05	Rolling uplands	50-80% of an area gently sloping, local relief variation ranges from 300-1000 feet and more than 50% of gentle slope is on upland.
13	Smooth Low Hills	20-50% of an area gently sloping and local relief variation ranges from 100-300 feet.
14	Smooth Mountain Lands	20-50% of an area gently sloping and local relief variation ranges from 300-500 feet.
19	High Hills	Less than 20% of an area gently sloping and local relief variation ranges from 500-1000 feet.
20	Igneous Fluvial	Less than 20% of an area gently sloping and local relief variation ranges from 1000-3000 feet.
22	Canyon - Scarp Lands	Extremely steep (75% plus) cliffs and rims, dominated by rock outcrops and colluvial slopes.
23	Glacial Depositional	Undulating to hilly landforms resulting from glacial deposition. Moraines, tills and outwashes typify the landscape.
24	Rock Outcrops	Exposures of bare rock greater than 80%.
25	Landslide Depositional	Areas of downward sliding or falling of relatively dry mass of earth, rock, or mixture of the two which have become loosened from a hillside by moisture, snow or man.

However, the mapping categories are succinctly defined and the landscape does not always express changes as succinctly as landtype association definitions. The method for consistent delineation is to perceive a typical area and draw a boundary so that it is more homogeneous within the boundary than the surrounding areas. Optimally, the region inside should not only be homogeneous, but distinctly different from those surrounding regions. Once the interpreter develops the "eye" for landform mapping at this small scale, the delineations are easily made. The rolling uplands and tablelands are difficult to separate. These two categories have been combined and are labeled rolling uplands. All other categories may be easily interpreted. Other features of the landscape besides landtype association are discernable. Three landslides were mapped. These all are relatively large areas and the location was known by the interpreter prior to mapping. However, their form was obvious and LANDSAT image resolution enabled delineation of large areas such as these. The characteristic form is hummocky surface, lack of well-defined drainage, lakes, and the "stop action" appearance of a moving mass. Avalanche tracks are readily obvious with the LANDSAT stereo model, and September frames rendered a better picture of the tracks than the January frames. One large rockslide was obvious on the September frames. Rock outcrops are difficult to delineate on both frame sets due to the close spectral resemblance to alpine grasslands. Rock outcrops can be easily determined with the aid of CAAT. A restriction to mapping features with this type of model was found to be the width of the Rapidograph point (size 000). Print enlargements of the LANDSAT frames would minimize this problem. A zoom transfer scope was used to transfer the landtype association maps on LANDSAT frames (scale 1:1,000,000) to the Durango 2° base map (1:250,000 scale).

An interesting application which should be pursued is the temporal combination of LANDSAT frames to form stereo models. The potential for information content is increased when viewing a Band 5 winter frame with a Band 7 summer frame. A variable light source which could be individually adjusted for the separate frames is necessary, because the relative "exposure" of temporally separated frames can be significant. When frames of different exposure, winter (with snow) and summer are viewed, the brighter frame overpowers the dimmer one and a stereo model is not obtained.

Future mapping efforts could utilize geometric pattern recognition of Department of Defense Mapping Agency (DODMA) topographic tapes overlaid on LANDSAT computer compatible tapes. An analysis system can be designed to delineate landtype associations on the basis of slope classes and land relief. The categories which can be integrated into a dichotomous recognition key are: bottom lands (01), rolling uplands (05), smooth low hills (13), smooth mountain lands (14), high hills (19), uneven mountain lands (20) and canyon scarp (22). The three miscellaneous categories, glacial depositional (23), rock land (24) and landslide depositional (25), cannot be classified with the others because they can occur with great irregularity, and are not defined on the basis of topographic expression. Rockland can be delineated on the basis of spectral pattern by computer aided analysis techniques (Hoffer, Fleming and Krebs, 1973). Thus, only landslides and

glacial deposits remain undetectable within the automated framework. With a gentle slope being defined as less than 20 percent, a dichotomous key is presented. The key has two distinct levels, the first being the percentage of a land area with gently sloping topography, and second, the amount of land relief present. Specific combinations of these two topographic expressions characterize eight of the eleven landtype association categories.



In the case of canyon scarp (22) an additional requirement is necessary in areas having greater than 75 percent slope. Not all possible combinations are found in the flow diagram. The incorporated combinations are found in the planning unit and characterize all of the land. For application to other areas, the dichotomous system can be reworked to fit the particular landscape. This may lead to a different set of combinations.

This dichotomous system of landtype association delineation is presented for future geometric pattern recognition algorithms. However, minimal human interaction can be incorporated to make this system feasible and practical with present technology. The method utilizes the DODMA tapes, corrected and displayed at 1:250,000. First, a 20% slope map is produced and an interpreter can draw in the gentle slope classes, $\geq 80\%$, 80-50%, 50-20%, and $\leq 20\%$. An alternate method is to have the computer print out a gentle slope class map and the interpretation is then not necessary. Second, a land relief map is produced and an interpreter can draw in the local relief classes, 0-100', 100-300', 300-500', 500-1000', and 1000-3000'. Again, an alternate method would be to have the computer print out a local relief class map. The final stage is to overlay the gentle slope map and local relief map and delineate the landtype associations as defined by the dichotomous key. With present technology, the manual overlay method would initially be more time consuming than the present method. However, it has the potential for more accuracy, paves the way for greater advances in the automated delineation methods, and is applicable for those areas where other tools, e.g. 7½' relief maps, are not available. The present method utilizes a combination of aerial survey and interpretation of 1:250,000 topographic maps, and takes approximately one man week to delineate landtype association for a planning unit size area (Brock, personal communication). The new method presented above has not been tested, and future experimentation is necessary to determine the validity.

D. 3. 2. Landtype Level.

With respect to landtype level (Table 3) analysis, the entire gamut of remote sensing tools were evaluated. This includes manual photo interpretation of air photos, SKYLAB, LANDSAT images, and computer enhancement of LANDSAT data produced by the digital display unit of LARS. Forest Service black and white aerial photography (1956-1957, scale 1:15840) of the entire planning unit is available. Similar black and white air photos which covered the Carson National Forest were available but these were not utilized. NASA underflight coverage is available for the western one third of the planning unit. These are on Mission 248, Roll 24, frames 3 to 102, in 1:60,000 scale, 9" x 9" CIR transparency format flown in September, 1973. This is a superior photographic product but was not utilized because it does not cover the area of immediate concern, the Rio Grande National Forest portion of the planning unit. A cursory examination of SKYLAB photography showed that most landtypes can be adequately mapped, but not at the detail afforded by larger scale photography. SKYLAB photography, which is at a scale of 1:3,000,000 and in 70 mm format was not analyzed in great detail because of the limited availability for most land areas.

The main analysis of remote sensing tools was done with LANDSAT imagery and computer enhanced products of LANDSAT MSS data produced by the digital display unit at the Laboratory for Applications of Remote Sensing (LARS), Purdue University. LANDSAT imagery is available for the entire land surface. Computer enhancement of such satellite data aids analysis. Such remote sensing products have potential for future earth resource analysis. Because LANDSAT records spectral information from the surface of the earth, supplementary data is necessary for successful landtype analysis. At 37° N Latitude, LANDSAT has 33% sidelap of frames taken one day apart. This sidelap forms a stereo model of the topography when viewed with a stereoscope over a light table. A three dimensional model is essential in delineation of landforms. There is stereo coverage for 60 percent of the planning unit with LANDSAT frames 1424-17132 and 1425-17190. A stereo pair was produced from multispectral scanner data from the two LANDSAT frames on the digital display unit at LARS of all bands as well as false color infrared displays.

One 7½ minute quadrangle (Summit Peak) was mapped at the landtype level from this false color infrared stereo pair produced on the digital display unit. The data was geometrically corrected and was displayed in bands 4, 5, and 7. A triple exposure was made with filters on color slide film and false color images at 1:1 and 1:4 pixel displays were produced. The landtype mapping was done on color print enlargements from the color slides. The enlargements had a scale of 1:297,000.

Several correlations between color and elevation can be drawn from the false color LANDSAT-derived prints and the topographic base map. The blue at higher elevations was bare rock, but at lower elevations represented arid brushland. Bright white in areas of steep terrain was found to be bare rock, whereas bright white and yellow in gentle terrain at high

Table 3. Landtype Definitions.

Ridge	A destructional denudational form which is a narrow elongated crest of a hill or mountain.
Flat	A remnant of a structural surface which is a broad and nearly level upland area.
Sideslope	A constructional denudational form which occupies the undifferentiated inclined portions of mountain land, found below the local interfluvium and above the fluvial bottomlands. A sideslope is composed of colluvium or colluvial-mantelled bedrock.
Toeslope	A constructional denudational form which is the depositional zone at the base of a hillslope and transitional to lowlands. It is distinguished from sideslope by a discrete change in slope gradient.
Bench	A destructional fluvial-denudational form which is long and narrow, gently inclined and built from constructional fluvial processes.
Floodplain	A constructional fluvial form which is adjacent to a river channel and inundated during annual highwater periods.
Alluvium	A constructional fluvial form which is composed of sand, gravel, cobbles or other transported material. Alluvium includes glacial outwash, or stratified drift that is stream built from glacial meltwater.
Alluvial Fan	A cone-shaped constructional fluvial-denudational form resulting from a tributary of high declivity running into the valley of a stream with less declivity. Alluvial fans include debris fans, or cone-shaped constructional denudational forms.
Landslide	Any constructional denudational form which displays evidence or a history of perceptible unit downward movement of a portion of the land surface.
Till	Any constructional glacial form.
Bare Rock	A miscellaneous landtype which occurs under all geologic formation processes and consists of any surface with more than 90% bare rock.
Alpine	A miscellaneous landtype which is the land surface above the absolute tree limit.

elevation was alpine. Red demarcates the transition zone from sideslope to alpine tundra which corresponds to the vegetation transition zone of knummholz from forest to alpine tundra. This was mapped as sideslope. Dark red found at lower elevations was mapped as sideslope and represented a high crown closure of the coniferous species. Light red found at lower elevations with little or no local relief was mapped as alluvium. This cover type represents riparian vegetation. Black areas were topographic shadow, and where some slope gradient could be observed was mapped as sideslope. Several landforms are mapped from stereo appearances alone, including large ridges, flat, and extensive landslides. Landtype features which can be accurately mapped from false color imagery of this type are large ridges, flat, sideslope, alluvium, extensive landslides, bare rock and alpine. The areal extent of the mappable features is accurate, however the boundaries appear generalized due to edge effects between spectral classes. The landtype features not discernable with the current data format are small ridges, toeslopes, benches, floodplains, alluvial fans, small landslides and till. Better stereo resolution is necessary to delineate these smaller landtype features. Reversal of the stereo pairs emphasizes the lower elevation features, e.g. toeslopes, benches, floodplains and alluvial fans. Current work is considering the possibility of mapping these landtypes using stereo reversal.

The Summit Peak quadrangle illustrates the landtype features that were observable on the digital display stereo pairs without utilizing topographic data. With better data transferral methods and greater resolution, this type of product has good potential. The advantages of this product are the large area of coverage, the relative ease of acquisition, and a framework as a base for more detailed mapping.

An independent evaluation of black and white stereo pairs in all four bands produced from the digital display unit was attempted. It was found that the information content with respect to landtype analysis was all the same. Band 5 (.6-.7 μ) provided the best resolution, due to tonal contrast. The mapping detail which is possible from black and white stereo pairs is less than that of the false color stereo pairs explained above. For this reason, no final maps were produced from these products. With the addition of more grey scale classes (30) and better photographic methods from the digital display unit the following landtypes could be accurately delineated from the LANDSAT system: large ridges, flat, sideslope, large landslide, fluvial bottomlands (collectively includes bench, floodplain, alluvium, and alluvial fan), bare rock and alpine tundra.

D. 3. 3. Comparison of Time Involvement.

A comparison of time involvement for mapping at the landtype association level and landtype level was made. The methods used by the Forest Service are based on black and white aerial photography and familiarity with the area through long-term field observation. The methods employed by INSTAAR involve the use of LANDSAT frames, computer enhanced display products from LANDSAT MSS data, and minimal exposure to the field situation. Before

any landtype level mapping could be done, the mapping categories had to be characterized and succinctly defined. A significant contribution made by INSTAAR to the planning effort of the Forest Service was the derivation of the landtype level characterization and mapping unit definitions.

Landtype Association Level Map for Planning Unit. (800,000 acres)

<u>INSTAAR</u>	<u>FOREST SERVICE</u>
(LANDSAT Frame)	(Aerial Photography)
8 hrs.	40 hrs.

Landtype Level Map of 7½' USGS Quadrangle.

<u>INSTAAR</u>	<u>FOREST SERVICE</u>
(Computer Enhanced Product)	(Aerial Photography)
Initial Observation 6 hrs.	3 hrs.
Actual Mapping 3½ hrs.	3.6-4.4 hrs.

Landtype Level Characterization for Entire Planning Unit.

<u>INSTAAR</u>	<u>FOREST SERVICE</u>
4 months	never done

Includes:

acquisition and orientation to aerial photos	-50 hrs.
API	-25 hrs.
transfer to Hurd photos	-33 hrs.
field checking	-12 days
field data acquisition	-12 days
final maps	-48 hrs.
data collection	-72 hrs.
program into computer	-18 hrs.
computer analyst time	-40 hrs.
final tabulation and interpretation	-18 hrs.
write-up	- 8 days/ 65 days total.

More time (4 months) is actually involved in the process of landtype level characterization than represented here. Specific needs for more

detailed information than the landtype association level emphasized the necessity for deriving the landtype level. Until six months ago, the landtype level classification for the Forest Service existed on paper only. The characterization and unit definitions were never done for the Southern San Juan Mountains Planning Unit, or any other planning area. The originality problems (Murphy's laws) encountered extend the time involvement. To repeat this process in another area would require one third of the time. The development of the design method for landtype level characterization (Loranger, 1975, unpublished M.A. thesis) establishes this process.

D. 3. 4. Summary.

Landtype association level can be accurately mapped from either the stereo portion of LANDSAT images or the computer enhanced products from LANDSAT MSS computer compatible tapes. Landtype level can be partially mapped from color infrared stereo pairs of derived computer enhanced products from LANDSAT data. A succinct characterization of the landtype level previously not done serves as a guide for future work with remote sensing systems. The LANDSAT MSS system generates the detail of information necessary to delineate landtypes, however, the technology for extraction of this data is not yet fully developed. By overlaying DODMA topographic data tapes on LANDSAT MSS computer compatible tapes, the number of mappable units may be increased. Slope, elevation, and aspect data can then be integrated with spectral data from the LANDSAT system. With the resultant characterization of landtypes, these products can be analyzed for rapid interpretation and delineation at the landtype level.

D. 4. Projected Activities.

Work on the preliminary vegetation classification by LARS is continuing. This classification will be completed in late September to allow the Forest Service to incorporate the derived information in their planning effort. The terrain modeling effort using the layered classifier and ecological information derived from the DODMA tapes to make classifying decisions will be started. The terrain modeling will hopefully provide a more accurate classification than the preliminary classification based on LANDSAT spectral data alone. Upon receiving the field data and maps from INSTAAR the data will be prepared for the computer to use in evaluating the classifications.

The INSTAAR team will prepare the test data point information in a format usable to LARS in the classification evaluation. The data must be transferred from field books to 3"x 5" cards, arranged in numerical sequence and typed. The cover type boundaries will be transferred to mylar overlays for the 7½' base maps. With the acquisition of NASA aerial photography some of the cover type boundaries may be extended. The area of the planning unit not intensely field checked will be examined for indications which may aid in the application of LANDSAT data to the Forest Service management problems. Some items of Forest Service concern include classification of recreation potential, Wilderness areas, Wild and Scenic rivers, water quality, and range quality. Field familiarity of the area combined with

the overview provided by aircraft coverage may lead to more applications of LANDSAT data and interpretations of practical use. Work on defining the ecological parameters of slope, elevation, and aspect of various species and communities is under way. Further refinement of this will result from interpretation of the summer's field data.

Work with the stereo modeling of LANDSAT images for a landtype level will continue. In an effort to make the system of use to the Forest Service, another researcher trained in geology using the method developed in this report and all useful materials such as topographic maps and geologic maps, plus the LANDSAT images will try to push the technique to the limits of applicability with the technology currently available. This will also provide an independent evaluation of the method for presentation to the Forest Service.

A discussion and training session for LARS, INSTAAR, and the Forest Service will be held in the fall after the completion of the preliminary vegetation classification and evaluation of the landtype level interpretation. This will be another session to familiarize Forest Service personnel with LANDSAT data, LARSYS products and to discuss interpretations with the working members of the consortium.

Bibliography.

- Brock, T. 1974. Landtype Association Level--Southern San Juan Mountains Planning Unit. Dept. of Agric., U.S. Forest Service, Rio Grande National Forest, 24 pp.**
- Hoffer, R.M., M.D. Fleming, and P.V. Krebs. 1974. Use of Computer-aided analysis techniques for cover type mapping in areas of mountainous terrain. Laboratory for Applications of Remote Sensing Information Note 091272, Purdue University, West Lafayette, Indiana, 14 pp.**
- Loranger, S. 1975 (unpublished M.A. thesis). Design method for landtype level characterization. University of Colorado, 63 pp.**
- Wertz, W.A. and J.F. Arnold. 1972. Land systems inventory. Dept. of Agric., U.S. Forest Service Intermountain Region, Division Soil and Water Management, Ogden, Utah, 12 pp.**

E. Significant Results.

No significant results are identified during this reporting period.

F. Publications.

No publications or presentations were completed during this reporting period.

G. Recommendations.

There are no recommendations to be made for this reporting period.

H. Aircraft data.

When training an observer for distinguishing landtype level features on computer enhanced LANDSAT data, aerial photography combined with field work is useful. The coverage used for this work was Forest Service natural color photography at the scale of 1:15,580. Natural color is not as helpful as color infrared. As explained in the first quarterly report, aircraft coverage will be necessary to proceed with the classification and evaluation of the LANDSAT MSS data tapes. NASA was able to fly aircraft coverage for the Southern San Juan Mountains Planning Unit during the last week of June, 1975. Although we have not seen this coverage as yet, the clear weather during that period of time should give good cloud free coverage. This flight was especially fortunate because the time regularly scheduled for the flight of the study area was mostly cloudy over the mountainous areas. The lack of complete stereo coverage may present problems, but we are pleased to have the coverage we were able to get.

I. Data Use.

Value of data allowed	\$1,536
Value of data ordered	\$ 244
Value of data received	\$ 125

Computer compatible tapes for LANDSAT -1 frame no. 1424-17132 were already in the tape files at LARS. This is the frame chosen from LANDSAT -1 MSS data which covers the entire test site. Reformatting the tapes from all four bands has been completed. A portion of this scene which includes the test site has been geometrically corrected by rotating, deskewing, and rescaling. The geometric correction was done for both the line printer output, as well as the digital display.

Tapes for the LANDSAT-1 frame no. 1425-17190 had previously been used by LARS for another investigation and had been reformatted and geometrically corrected. This data includes 60% of the test site and was used for stereo pairing.

LANDSAT-1 frames 1190-17145 and 1191-17204 were used in the stereo modeling for temporal data evaluation.

- 24 -
ERTS IMAGE DESCRIPTOR FORM
 (See Instructions on Back)

DATE August 31, 1975

PRINCIPAL INVESTIGATOR Dr. Paula V. Krebs

GSFC #376

ORGANIZATION Institute of Arctic and Alpine Research

NDPP USE ONLY

D _____
 N _____
 ID _____

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	vegetation	land	forms	
LANDSAT -1				
1424-17132 M,D	X		X	tundra, grassland,
1425-17190 M,D	X		X	meadow, shrub, forest,
1190-17145 M,D	X		X	water, rock outcrops
1191-17204 M,D	X		X	bottomlands, rolling
				uplands, smooth low hills,
				smooth mountain lands,
				high hills, uneven
				mountain lands, canyon
				scarp lands, glacial
				depositional, rock out-
				crops, landslide depositional,
				ridges, flat, sideslope,
				alluvium, alpine

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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J. Funds Expended.

First quarter	Subtotal	\$76,210
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Second quarter
(June 1 through August 31, 1975)

Salaries and wages	\$ 8,656
Indirect costs, supportive services	2,530
Consultant fees	3,000
Travel and field expenses	1,515
Materials	129

Subtotal	\$10,831
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TOTAL	\$87,041
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